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Description

Method for transmitting data in a radio communication system

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The invention relates to a method for transmitting data in a radio communication system, in particular in mobile radio systems with a broadband radio interface, which are called UMTS (universal mobile telecommunication system).

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In radio communication systems, data are transmitted via a radio interface using electromagnetic waves. The radio interface refers to a connection between a base station and subscriber stations, with the subscriber stations being able to be mobile stations or stationary radio stations. In this context, the electromagnetic waves are radiated at carrier frequencies situated in the frequency band provided for the respective system. For future radio communication systems, for example the UMTS mobile radio system or other 3rd generation systems, frequencies in the frequency band of approximately 2000 MHz are provided, with the bandwidth of a channel being 5 MHz.

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By contrast with systems like GSM (global system for mobile communications), a plurality of services which can also be transmitted in parallel is provided for the UMTS mobile radio system. Patent specifications EP 98 122 719 and DE 198 55 194 describe options for signaling the transport formats for the combination of data for a plurality of services. The data for a plurality of services on a connection are transmitted via a jointly used physical channel in this case.

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The use of jointly used physical channels for transmitting data for a plurality of services on a connection to a subscriber station presupposes that a unique mapping specification indicates the allocation of the services to different segments of the physical channel.

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By way of example, a physical channel is defined by a frequency band and a spread code (CDMA code division multiple access) within a frame.

- 5 The following terms are customary for describing the mapping specification:

Transport Format (TF):

- 10 A transport format defines a data rate, a coding, scrambling (interleaving), a data rate adjustment by puncturing and an error protection specification for a transport channel for a service.

Transport Format Set (TFS):

- 15 This denotes a set of possible transport formats which are permitted for a specific service.

Transport Format Combination (TFC):

- 20 This term indicates a possible combination of transport formats for the various services which are mapped onto a common physical channel.

Transport Format Combination Set (TFCS):

- 25 This denotes a set of possible TFCs as a subset of all TFCs which are permitted for a specific connection.

Transport Format Combination Identifier (TFCI):

- 30 This information item indicates the currently used combination of transport formats within the TFC.

- 35 In order to be able to select the currently used combination of transport formats for the various services in line with requirements, the TFC needs to be able to be changed, and hence the TFCI needs to be signaled regularly. This signaling ties up transmission

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capacity, however. The greater the number of possible combination options (TFCS), the more capacity is required for signaling.

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5 In the case of the broadband CDMA system chosen for the  
FDD mode (FDD frequency division duplex) for the UMTS  
mobile radio system, when transmitting from the base  
station to the subscriber station in the downlink  
direction, the problem arises that the number of  
orthogonal spread codes which are too useful at the  
same time is limited, which makes it more difficult to  
support variable data rates. Thus, with relatively high  
traffic densities in the system, it is not possible to  
10 allocate to all subscriber stations as many dedicated  
(i.e. used exclusively by the subscriber station)  
channels (DCH) as they need for transmission at their  
respective highest data rate.

15 For this reason, common channels, "shared channels"  
(DSCH downlink shared channel), are defined in the  
downlink direction, in this regard cf. ETSI, SMG2,  
UMTS-L1, Tdoc SMG2 UMTS-L1 559/98, dated November 9,  
1998. The common channels are formed within the  
20 broadband frequency band by spread codes which are  
temporarily allocated to various connections or  
subscriber stations for the duration of one or more  
frames in each case. In this context, however, the  
problem arises of how it is possible to signal to a  
25 subscriber station with minimum complexity whether  
information is being transmitted for the subscriber  
station, and if so in which of these common channels.

In addition, ETSI SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1  
30 559/98, dated November 9, 1998, discloses that the data  
rates for the services transmitted using time-division  
multiplex are signaled using the TFCI parameter, which  
is transmitted during each frame as part of the control  
information, i.e. in-band. To ensure rapid allocation  
35 of common channels, explicit signaling is proposed  
which uses a particular number of these TFCI bits

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exclusively for the purpose of indicating a particular  
spread code (cf. penultimate page).

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This solution has the drawback that, as a result of this, for a given number of TFCI bits, the number of combination options for transport formats for the services is significantly limited, which has a  
5 considerable effect on flexibility when transmitting variable data rates.

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10 The invention is based on the object of specifying a method and a radio communication system which, when using common channels for a plurality of connections, increase the flexibility of resource allocation when transmitting variable data rates. This object is achieved by the method based on the features of claim 1 and by the communication system based on the features  
15 of claim 10. Advantageous developments can be found in the subclaims.

20 The invention is based on the idea of implicitly signaling the used common channels using the data rate, and of permitting a plurality of combinations of channels (spread codes) as alternatives only for particular data rates for the individual services. This saves transmission capacity, because there is no need to reserve any individual bits within the TFCI  
25 parameter just for allocating the common channels to different connections. The data rate is signaled in-band, with this information relating to the data rate not needing to be contained in full in each frame. Information from the connection context or from  
30 preceding frames can likewise be used for determining the data rate.

In accordance with one advantageous development of the invention, mapping the same combination of transport  
35 formats for the services onto various channels using the TFCI allows a very high degree of flexibility can

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be achieved for minimum signaling complexity.

The relationship between allocated data rate and common channels to be used is agreed in a

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separate signaling channel, so that the receiver is able to derive the chosen combination of channels, including one or more common channels, from the respective value of the TFCI parameter. This signaling of the relationship (mapping specification for the TFCI values onto stipulated combinations of the transport formats) advantageously occurs upon connection setup between base station and subscriber station. The data rate for the TFCI in-band signaling is high and uses considerable transmission resources. If it is possible to make savings here by virtue of generally valid agreements at the start of connection, then the number of TFCI bits required can be reduced, or the number of combination options can be increased.

The method according to the invention and its advantageous developments give rise to the following advantages:

- With purely implicit signaling, there is no additional signaling complexity, which means that the available TFCI bits can be used exclusively for signaling the combination of data rates for the individual services with very fine granularity.
- Implicit signaling permits a high maximum transmission capacity to be allocated for each connection. The resultant dependencies of the possible data rates between the connections become less significant the more connections are involved and common channels are available.
- The additionally possible allocation of the same service combinations to various common channels using a respective unique TFCI value permits a very high degree of flexibility to be achieved.
- The complexity for signaling common channels can

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be matched very precisely to the requirements of the connection and need not involve whole bits.

- The use of common channels can be limited to particular, higher-rate service combinations or those with high data rate dynamics, while low-rate

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service combinations are transmitted exclusively using dedicated channels.

- It is possible to allocate common channels on a connection-oriented basis and dynamically, depending on the current number of used channels.

Exemplary embodiments of the invention are explained in more detail with reference to the appended drawings, in which

- 10 Figure 1 shows a schematic illustration of a radio communication system,
- Figure 2 shows a layer model of the transmission protocols,
- 15 Figures 3, 4 show data for various services mapped onto jointly used physical channels,
- Figures 5, 6 show tables containing allocation options for common channels for a plurality of connections,
- 20 Figures 7, 8 show ambiguous allocations and hence reduction in the likelihood of blockages, and
- Figure 9 shows data transmission in frames with in-band signaling.

- 25 The mobile radio system shown in Figure 1 as an example of a radio communication system comprises a multiplicity of mobile switching centers MSC which are interlinked and set up access to a landline network PSTN. In addition, these mobile switching centers MSC
- 30 are connected to at least one respective device RNM for controlling the transmission resources. Each of these devices RNM permits, in turn, a connection to at least one base station BS.

- 35 A base station BS can set up a connection to subscriber stations, e.g. mobile stations MS or other mobile and

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stationary terminals, via a radio interface. Each base station BS forms at least one radio cell. Figure 1 shows connections for transmitting user information between a base station BS and

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mobile stations MS. Within a connection V1, data for, by way of example, three services S (S1, S2, S3) are transmitted within one or more physical channels Phy CH, and signaling information, e.g. the allocated  
5 radio system resources for a connection V1, is transmitted via a monitoring channel FACH (Forward link Access CHannel) which accompanies the connection.

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10 An operation and maintenance center OMC provides monitoring and maintenance functions for the mobile radio system or for parts thereof. The functional scope of this structure can be transferred to other radio communication systems in which the invention can be used, in particular for subscriber access networks with  
15 wireless subscriber access.

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20 In the radio communication system shown in Figure 1, both the base stations BS and the mobile stations MS are provided with transmission means and signaling means which communicate with one another. The transmission means are used for transmitting data for a combination of a plurality of services S via the currently available physical channels Phy CH. The physical channels Phy CH may be in the form of  
25 dedicated channels DCH, i.e. used exclusively by one connection, or in the form of common channels DSCH, i.e. used alternately by different connections V1, V2. A distinction therefore needs to be drawn between physical channels Phy CH jointly used by a plurality of  
30 services S1, S2, S3 on a connection V1 and common channels DSCH, which are allocated to a plurality of connections V1, V2 but is allocated to just one of the connections V1 or V2 for use during a period of time. The allocation of a common channel DSCH can be changed  
35 very rapidly from frame to frame without additional

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signaling complexity. The use of a common channel DSCH  
by different connections at successive times permits,  
in particular, good correspondence to the high data  
rate and high dynamics of the data rate of some  
5 connections V1 V2.

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1 The signaling means determine TFCI values for the  
selected combinations of transport formats TF for the  
services S1, S2, S3 and perform in-band signaling of  
the transport formats TF. In the separate channel FACH,  
5 the mapping specification for TFCI value to combination  
of transport formats TF and used channels DCH, DSCH is  
signaled.

10 The layer model shown in Figure 2 shows the protocols  
of the radio communication system divided into three  
layers.

15 Layer 1: physical layer for describing all the  
functions for bit transmission via a physical medium  
(e.g. coding, modulation, transmission power  
monitoring, synchronization etc.),

Layer 2: data link layer for describing the mapping of  
data onto the physical layer, and monitoring thereof,

20 Layer 3: network layer for controlling the resources of  
the radio interface.

Layer 3 stipulates the TFCs for a connection, while  
layer 2 selects a combination (of a TFC) which is  
signaled in-band using a TFCI, as shown later.

25 The parameter exchange between layers 1 and 2 supports  
the functions of transferring frames with data for  
layer 2 via the radio interface and of displaying the  
status of layer 1 to higher layers. The parameter  
exchange between layers 1 and 3 supports monitoring of  
30 the configuration of the transmission in layer 1 and  
generates system information relating to layer 1.

35 In this case, the mapping of the data for various  
connections S onto a common physical channel Phy CH and  
the signaling

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of the allocation of a common channel DSCH correspond to the interaction of layers 1 and 2.

Figures 3 and 4 show the need for transport formats TF  
5 to be signaled for currently transmitted services.

Figure 3 shows, as an illustration of function, a coding and multiplex unit which maps data from a plurality of data channels DCH (which each correspond to the data for a service S1, S2, S3) onto a coded common transport channel CCTrCH. In this context, mapping is a specification governing the bit pattern which is to be used for entering the data into a serial data sequence. A demultiplexer/allocation means  
10 distributes the data for the coded common transport channel CCTrCH over a plurality of physical channels Phy CH. The physical channels Phy CH are thus constantly used to transmit data for a plurality of services S1, S2, S3 in each case. A physical channel  
15 Phy CH is not allocated to one service S1 or S2 or S3 alone, but rather is allocated to the coded common transport channel CCTrCH with all its services S1, S2, S3.

Since the reception end needs to reconstruct this mapping and needs to read the data from the physical channels Phy CH and present them again in separate transport channels DCH for the services, signaling is necessary. This signaling in the form of TFCI values  
20 depicts the currently used combination of the transport formats TF for the services and, as shown later, also the current allocation of a common channel or of a plurality of common channels DSCH. It has been agreed at connection setup which combinations are permitted  
25 for the connection (TFCS).

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Two options in the relationship between data rate and service combinations can be implemented (cf. also EP 98 122 719):

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1. Each data rate GR corresponds to precisely one combination of transport formats TF.
2. For each data rate GR, a plurality of combinations of transport formats TF are possible which can be distinguished using TFCI values.

Figure 4 shows the mapping in a slightly modified form, with it becoming clear that the partial information item TFCI need be signaled only when physical channels Phy CH are jointly used by a plurality of services S1, S2, S3. If a service S1 or S2 or S3 uses one physical channel Phy CH exclusively, then signaling of the partial information item TFCI can be dispensed with.

The allocation of a common channel DSCH to a connection V is shown with reference to Figures 5 and 6 using an example having two mobile stations MS and hence two connections V1, V2. Let it be assumed that the connections 1 and 2 can each transmit their data using the data rates of 16, 32 and 48 kbps, with three common channels DSCH each having 16 kbps being available for both connections V1, V2. For the two connections V1, V2, the tables shown in Figures 5 and 6 each stipulate which of these common channels DSCH can be used to transmit which data rates. This table has been stipulated at the start of connection, but may also be changed concurrently with the connection.

Since the two connections V1, V2 exist in parallel, only particular combinations of the data rates are permitted, in order to prevent simultaneous use of the common channels DSCH. These are indicated in the table shown in Figure 7.

In this example, only 10 of 16 possible combinations are permitted. All the combinations in which more than

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16 kbps are transmitted simultaneously for the two  
connections V1, V2 must be excluded.

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In general, the described implicit allocation of common channels DSCH allows the available channels to be split over all the connections V1, V2 with such flexibility that each individual connection V1, V2 is able to use a much higher transmission capacity than in the case of fixed allocation of the channels as dedicated channels DCH.

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10 In this case, for statistical reasons, the limitation to particular combinations becomes less significant the more connections V1, V2 and common channels DSCH are available, if it is assumed that the ratio of the maximum data rate required by all connections V1, V2 to the data rate which is possible as a result of the use of all common channels DSCH remains constant.

20 An additional degree of freedom is possible if not every data rate has a fixed mapping, i.e. uniquely onto prescribed TFCI values, but instead alternatives can be chosen. For the purposes of illustration, Figure 8 shows, for a connection V1, the incorporation of the configuration of the common channels DSCH into the information signaled by the TFCI values.

25 A TFCI value represents a particular configuration of the services S1 to S3. To date, only one TFCI value for each permitted combination was appropriate. The extension by the configuration data for the common channels DSCH can now be used to allocate a particular service combination to different combinations of dedicated and common channels DCH, DSCH. In Figure 8, the TFCI values 2, 3 and 4 relate to the same service combination, but different allocated common channels DSCH are signaled.

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If this table is allocated to a plurality of connections V1, V2, various common channels DSCH can be chosen as alternatives by selecting a suitable TFCI value 2, 3 or 4, in order to permit a high data rate for up to

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three connections V simultaneously. By contrast, the low total data rate in the second row can always be transmitted in the permanently allocated dedicated channel DCH; for this reason, no common channel DSCH is  
5 necessary for this purpose.

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The in-band signaling of the TFCI values is effected as shown in Figure 9. Within frame-by-frame transmission of data (data) together with other information, capacity is also provided for transmitting the  
10 currently chosen combination of the transport formats TF and allocation of the common channels DSCH in the form of the TFCI values. In the FDD mode of UMTS, a frame lasts 10 ms, with bits of a pilot sequence  
15 (pilot) serving for channel estimation, bits (pc) being required for transmission power regulation and bits being reserved for in-band signaling of the TFCI. Next comes a data component data with user information. Error protection coding of the TFCI on, by way of  
20 example, 32 bits and scrambling of the user information over a plurality of frames are not shown in Figure 9.

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